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A PRELIMINARY ASSESSMENT OF THE VIBRATORY RING PULVERISOR USING SELECTED NON-METALLIC MINERALS

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by

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SUMMARY

The vibratory ring pulverisor has been investigated as a technique for fine grinding quartz, barite, limestone and talc/dolomite. A series of grinding curves expressing % passing 25 µm vs time have been prepared for 15 g, 50 g and 100 g portions of the selected minerals. Initial indications are that grinding times required to achieve 100% minus 25 µm for the hardest mineral, quartz, are 2 min for 15 g, 7.5 min for 50 g; for 100 g, 90% minus 25 µm was achieved after approximately 22 min.

When the technique is used as a method of preparing samples for chemical analysis, the unit should not be used for grinding non-metallic minerals with an alumina content of less than 0.9% Al_2O_3, and in particular, high grade silica glass sand with an alumina content of less than 0.15% Al_2O_3, since extraneous alumina from the grinding surfaces will alter the analysis value. Above, 0.9% Al_2O_3 the error between the true and the spurious analysis becomes negligible.

ÉVALUATION PRÉLIMINAIRE DU PULVÉRISATEUR ANNULAIRE VIBRATOIRE À L'AIDE DE MINÉRAUX NON MÉTALLIQUES SÉLECTIONNÉS

par

P.R.A. Andrews et G.A. Brown

RÉSUMÉ

On a investigué les possibilités du pulvérisateur annulaire vibratoire en tant que technique de broyage fin du quartz, de la barytine, du calcaire et des mélanges talc-dolomite. Une série de courbes de broyage exprimant en pourcentage le temps requis pour le broyage à 25 µm de portions de minéraux de 15 g, 50 g et 100 g. dans une période donnée a été élaborée. Les premiers indices démontrent que la période de broyage requise pour obtenir un taux de pulvérisation de 100 % à - 25 µm pour le minéral le plus dur, le quartz, est de 2 min pour 15 g, et de 7,5 min pour 50 g ; dans le cas d'une portion de 100 g, on a obtenu un taux de broyage de 90 % à moins 25 µm sur une période d'une durée d'environ 22 m.

Quand la technique de pulvérisation est employée comme méthode de préparation des échantillons, il est préférable de ne pas utiliser le pulvérisateur pour broyer les minéraux non métalliques qui ont une teneur en alumine inférieure à 0,9 % Al_2O_3, et en particulier le sable réfractaire utilisé dans la production du verre et dont la teneur en alumine est de moins 0,15 % , car l'alumine en surplus provenant des surfaces de pulvérisation modifiera la valeur de l'analyse. Quant à la pulvérisation des minéraux ayant une teneur supérieure à 0,9 % Al_2O_3, la marge d'erreur entre une analyse exacte et une analyse erronée est négligeable.

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INTRODUCTION

In March 1982 a vibratory ring pulverisor was purchased from T.M. Engineering, Vancouver, B.C. The pulverisor[1] consisted of:

1. Sound damping enclosure with hinged cover
2. Vibratory body with clamping system
3. A 3 phase 220/440 volts, ¼ H.P. electric motor
4. Control panel containing a push-on button, an emergency push-off button, and a digital timer that can be set at 1 sec intervals up to 999 secs.
5. A fused alumina ceramic lined grinding barrel, 120 mL capacity containing a solid ceramic centre stone and a ceramic concentric ring.

The pulverisor was secured to a concrete floor by four 6 mm thick, 90° angle plates; the plate side adjacent to the floor being bolted and the plate side adjacent to the pulverisor being welded.

PRINCIPLE OF OPERATION

The principle of operation is based on an eccentric attached to the motor shaft; with the motor in operation the eccentric causes a rotational motion to be imparted to the vibratory body. The grinding barrel is attached to the vibratory body by a swing arm clamping device, enabling the rotational motion of the vibratory body to be imparted to the grinding chamber. Inside the grinding barrel grinding is achieved by the rotation of the centre stone against the concentric ring and the rotation of the concentric ring against the inner surface of the grinding barrel.

METHOD OF OPERATION

The mineral to be ground is added to the grinding barrel, evenly distributed between the ring and barrel side and between the centre stone and concentric ring, making sure that no mineral particles remain on the top of the grinding elements. The grinding lid is then placed in position

and the whole grinding barrel assembly is locked securely onto its seat on the vibratory body by means of the swing-arm clamping device. The hinged cover is closed, the required grinding time set on the digital timer and the grinding cycle started. At the end of the grinding cycle the pulverisor switches off automatically. The grinding barrel is removed and the ground mineral removed from the grinding barrel. This latter operation is best performed by removing the centre stone first, followed by removal of the concentric ring. Both centre stone and concentric ring are brushed to remove adhering mineral and finally the remaining ground mineral in the grinding barrel is brushed out.

SCOPE OF STUDY

Grinding time depends principally upon weight, hardness and initial particle size of the mineral to be ground. In respect to weight of mineral the information available[1] quotes only volume capacity and the maximum initial particle size is quoted as 15 mm for relatively soft dolomite to 5 mm for harder ferro-alloys.

This preliminary study was therefore directed towards establishing these basic parameters for selected non-metallic minerals. The minerals chosen, shown in Table 1, represent a range from very hard, silica; very dense, barite and very soft, talc/dolomite, with limestone having an intermediate hardness.

TABLE 1. Selected non-metallic minerals for grinding

Mineral	Initial Size	Hardness	Specific Gravity
Silica	-4.76 mm	7	2.65
Barite	-4.76 mm	3.3	4.50
Silica	-600 µm	7	2.65
Limestone	-600 + 125 µm	3.5	2.63
Talc/Dolomite*	-600 µm	2.0	2.92

*Approximately 60% talc

The high initial size of minus 4.76 mm was chosen as this is the suggested maximum size for hard material[1]; the lower minus 600 µm size was chosen as corresponding to an intermediate size.

TESTWORK PROCEDURE

An initial test was conducted using Ottawa silica sand (minus 600 plus 150 µm) to determine the maximum weight of typical glass sand material that can be effectively ground to 98% minus 75 µm. The results depicted in Fig. 1 show the time necessary to achieve 98% minus 75 µm with increasing weights of silica sand. Physical observation suggested that 125 g was the maximum. The maximum weight will also depend on specific gravity. A similar series of tests conducted on minus 4.76 mm barite also shown in Fig. 1, suggested that 200 g was the maximum.

Based on this initial study, a detailed grinding evalution on silica, barite, limestone and talc/dolomite was conducted at three separate weight levels of 15 g, 50 g and 100 g, for various grinding times. The lower figure of 15 g was chosen as this is the weight usually required for chemical analysis and preparation of samples for chemical analysis is one of the main uses of the pulverisor.

After each grinding test the ground product was wet screened on a 25 µm screen. The dried oversize was then screened from 150 µm through to 25 µm and each fraction weighed. The detailed size analyses of each ground product was then calculated and the results tabulated under each mineral in Tables 4 to 8 - Appendix. The results are also shown as cumulative % passing 25 µm vs logarithmic time in Fig. 2 to 6.

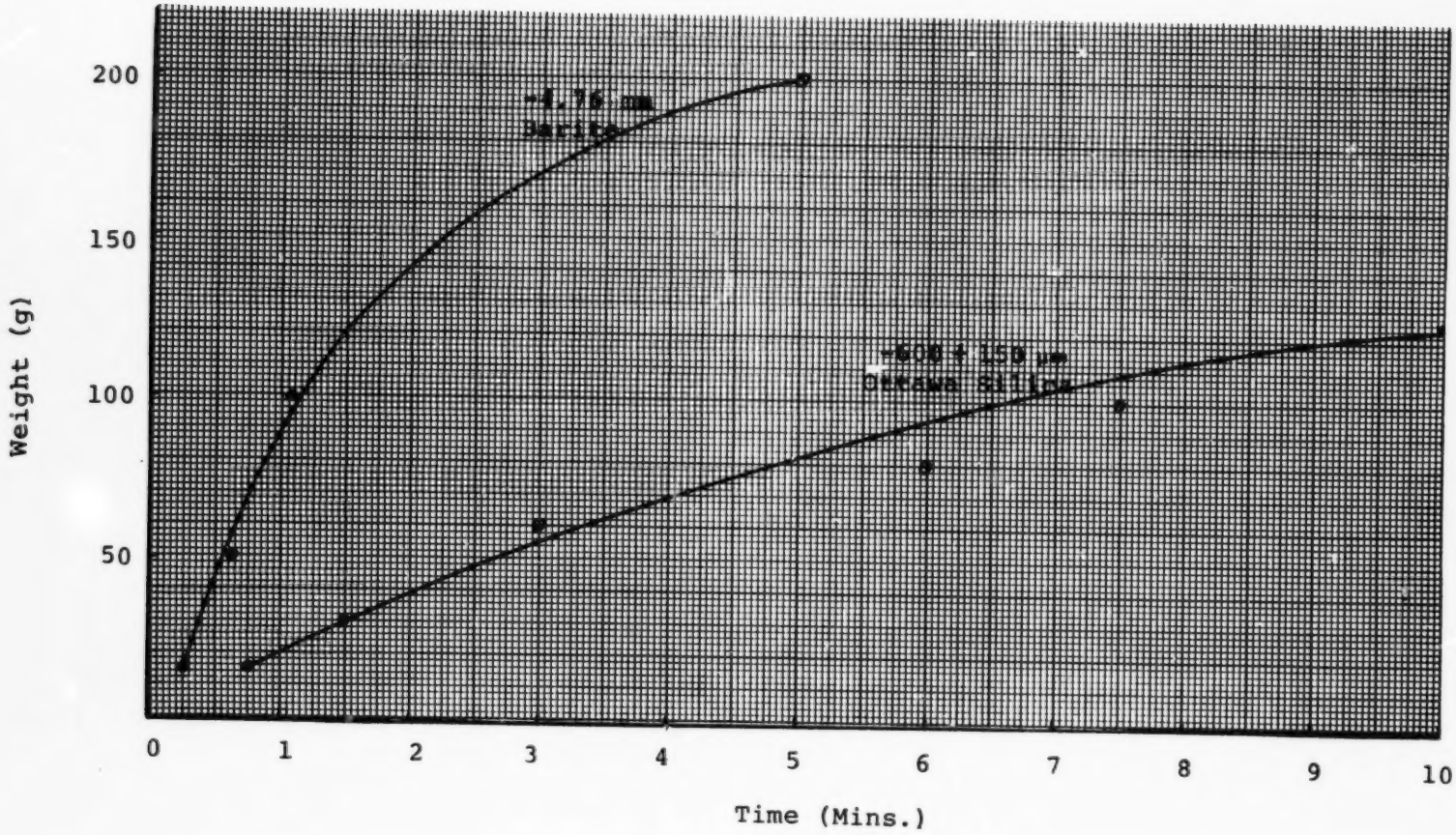

Fig. 1. Grinding rates for barite and silica

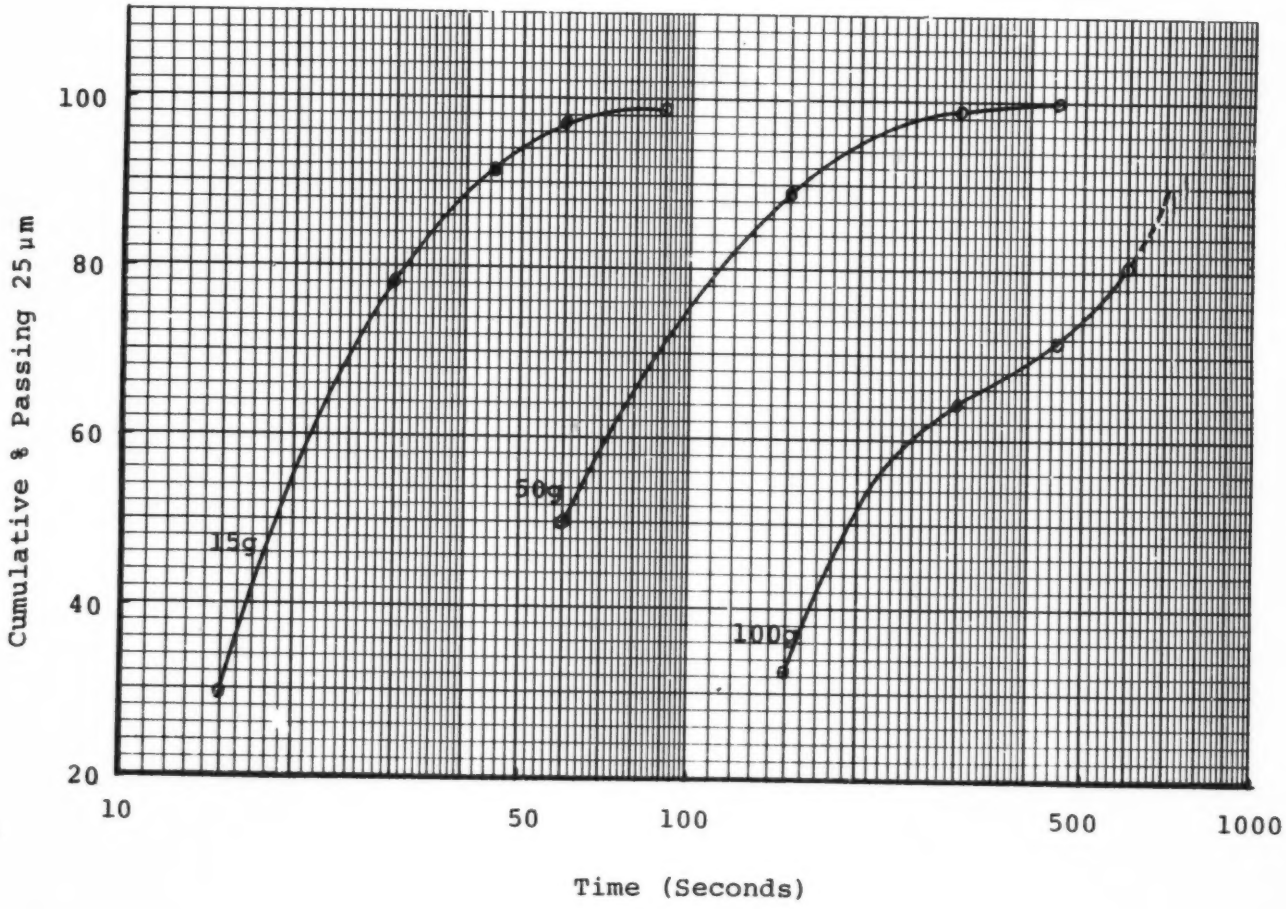

Fig. 2. Grinding characteristics for -4.76mm silica

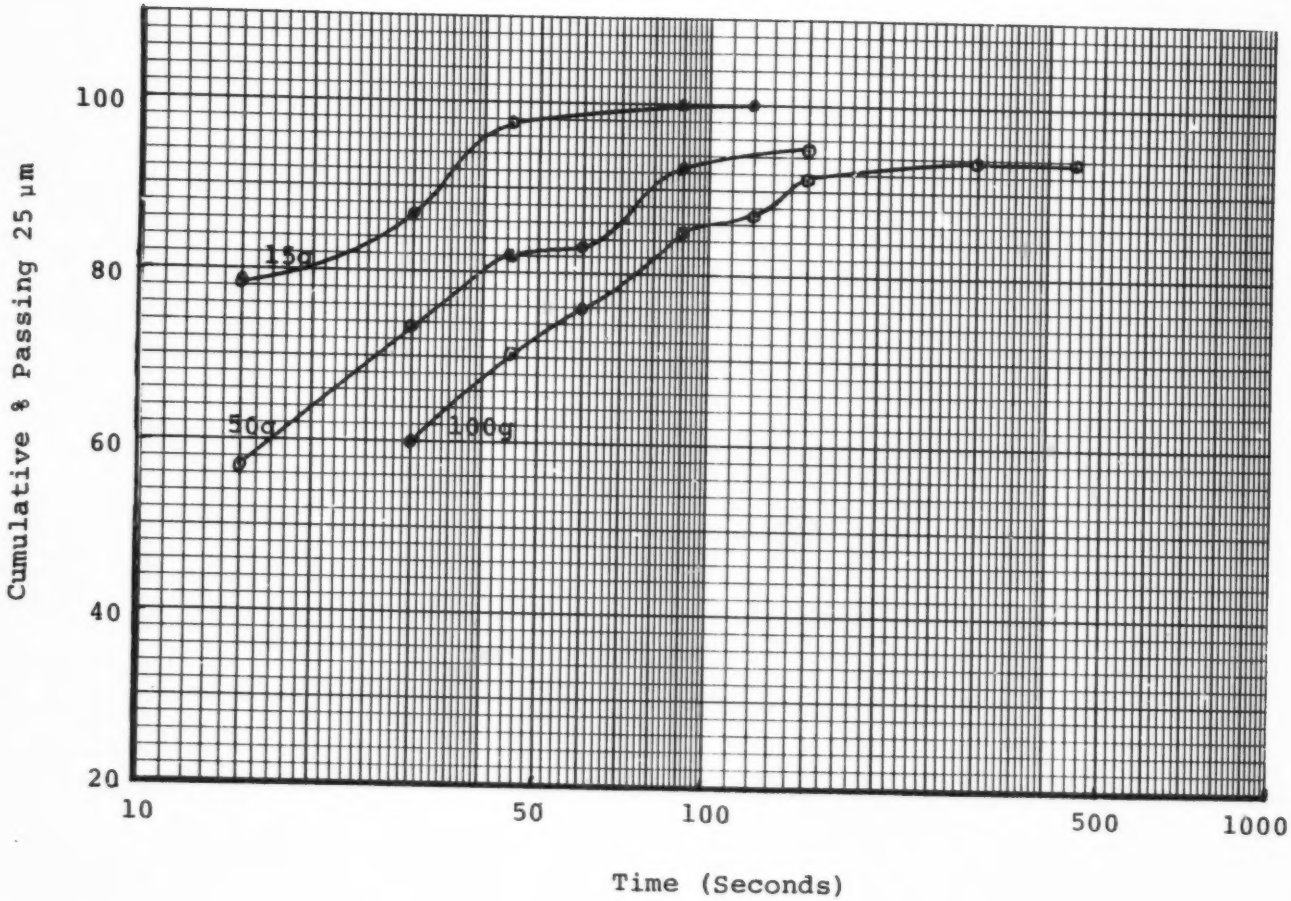

Fig. 3. Grinding characteristics for -4.76mm barite

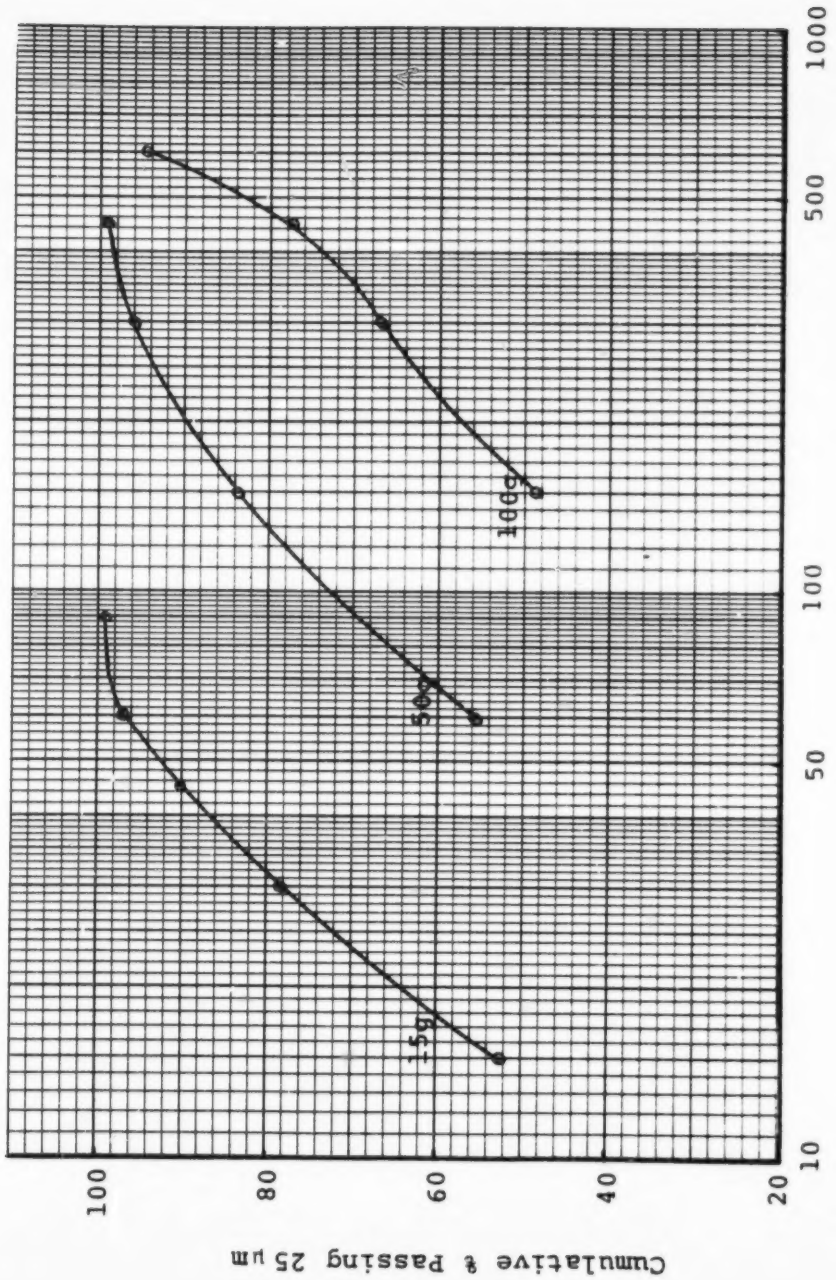

Fig. 4. Grinding characteristics for -600 µm silica

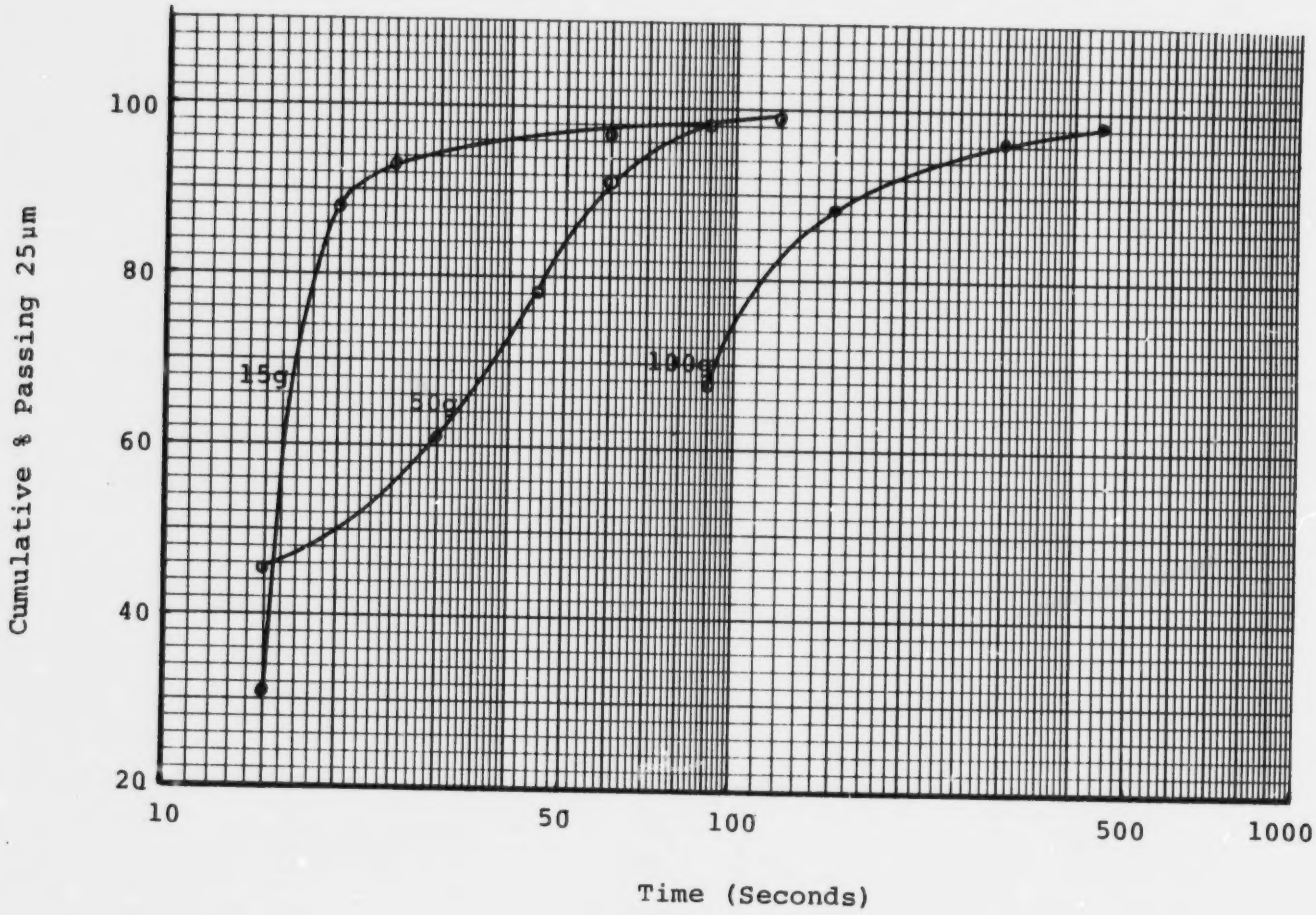

Fig. 5. Grinding characteristics for -600 + 125µm limestone

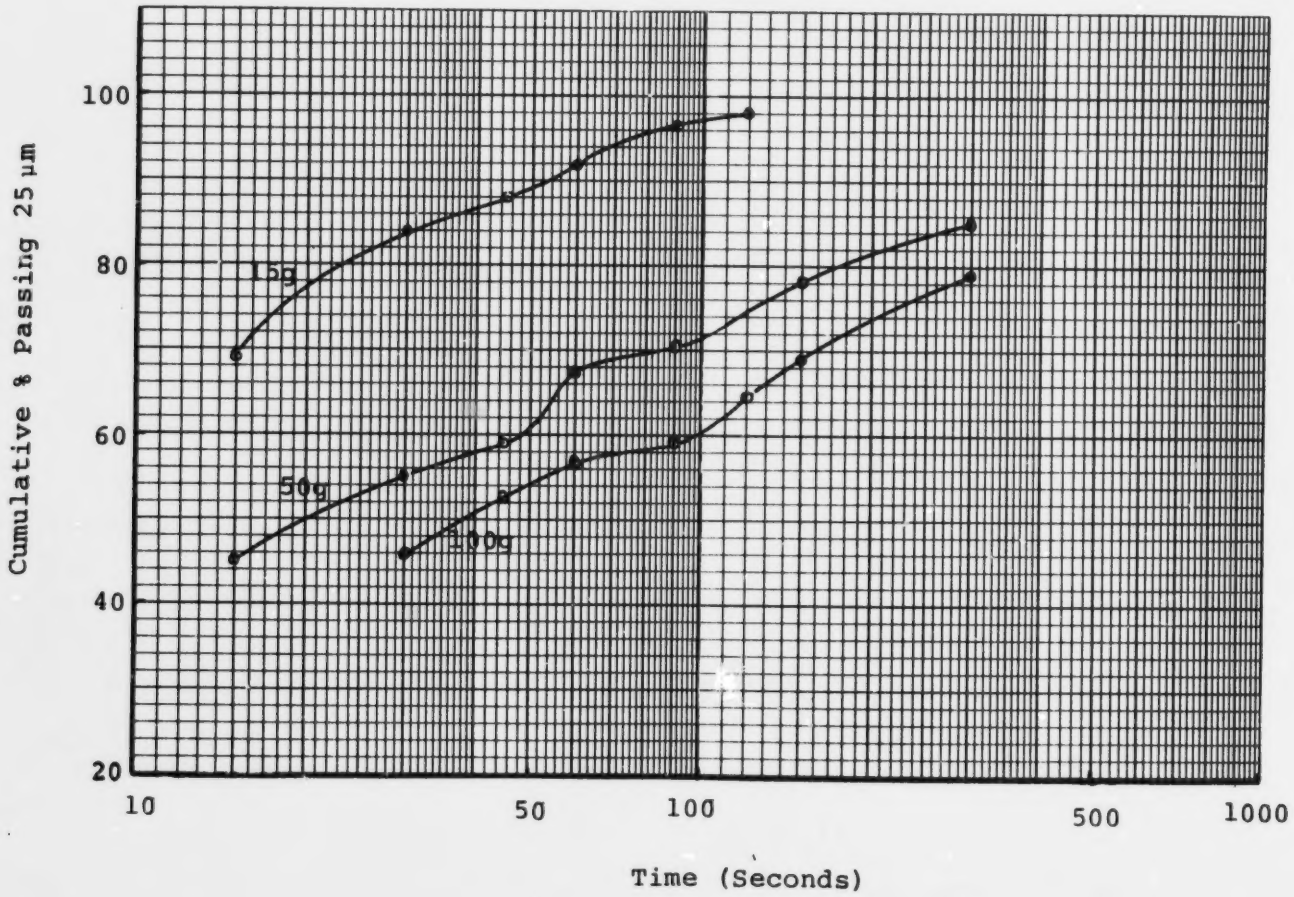

Fig. 6. Grinding characteristics for - 600µm talc/dolomite

ALUMINA ANALYSIS

Since the grinding chamber, ring and stone are constructed of fused alumina there is the possibility of contamination of ground samples by extraneous spurious alumina from the grinding surfaces. Of particular concern are high purity silica sands which are less than 0.05% Al_2O_3. To determine the extent to which spurious alumina will contaminate silica sand, a series of samples were prepared in duplicate, representing a range of alumina analyses from 0.06 to 4.00% Al_2O_3.

The first sample from each duplicate pair was ground to minus 75 µm using the vibratory ring pulverisor while the second sample was ground to minus 75 µm using a laboratory mechanical agate pestle and mortar which does not produce spurious alumina. This procedure was repeated for each duplicate pair of samples. On completion of grinding all samples were analysed for Al_2O_3 using a spectrographic technique; the variation in analysis between the two grinding methods can be seen in Table 9 - Appendix. The ratio between the spurious analysis and the true analysis for increasing alumina analyses is also shown in Fig. 7.

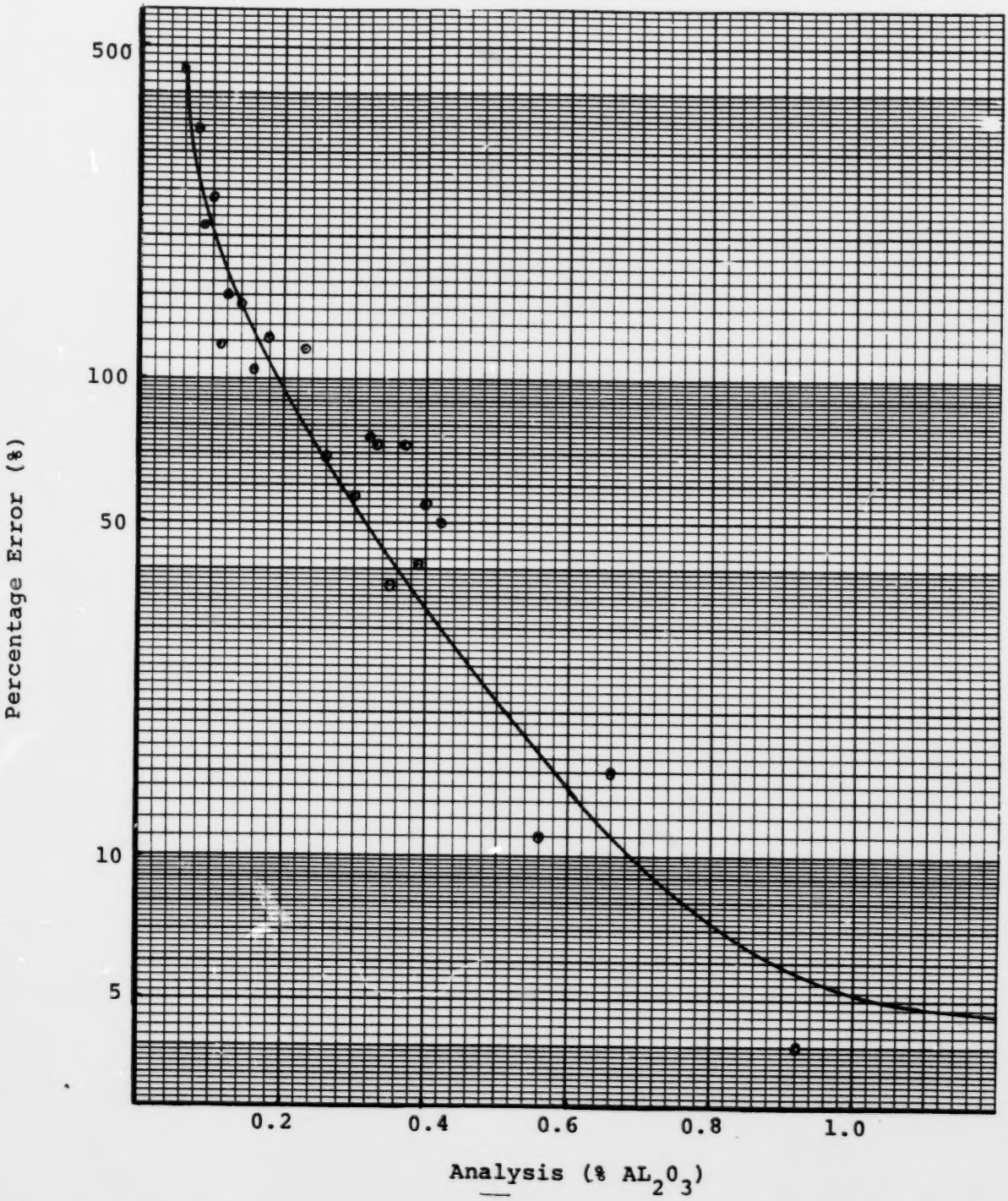

Fig. 7. Reduction in error between spurious and true alumina analyses, with increasing true analysis values

DISCUSSION OF RESULTS

Each mineral produced a series of grinding curves, at each weight interval, of the type that is normal for fine grinding.

The grinding times required to produce 90% minus 25 µm for each mineral at both minus 4.76 mm and minus 600 µm feed sizes are summarized in Table 2.

TABLE 2. Grinding times required to provide 90% -25 µm

Weight	Silica -4.76 mm (sec.)	Borite -4.76 mm (sec.)	Silica -600 µm (sec.)	Limestone -600+125 µm (sec.)	Talc/Dolomite -600 µm (sec.)
15 g	42	37	45	21	53
50 g	157	79	200	58	
100 g	760	138	565	166	

Considering minus 4.76 mm silica and barite, as might be expected, the difference in grinding time between the two minerals required to produce 90% minus 25 µm is more with the 100 g than with 15 g. For 15 g the difference in grinding time is more marked rather after 15 sec, where for silica 29.7% minus 25 µm was produced whereas for barite 78.8% minus 25 µm was produced.

At the lower minus 600 µm feed size the grinding times for silica and limestone are as would be expected but the grinding times for talc/dolomite are not consistent with the low hardness values for talc. This anomolous behaviour may be due to the presence of two hardness phases. Initial reduction of the soft phase is accomplished first, but subsequent reduction of the harder material may be impeded by the now much finer softer phase. Alternatively, the self lubricating property of ground talc may be impeding further grinding. That initial reduction is relatively fast can be inferred by the grinding times required to produce minus 75 µm which are reported for each mineral at both minus 4.76 and minus 600 µm feed sizes in Table 3.

TABLE 3. Grinding times required to produce 99 to 100% -75 µm

Weight	Silica -4.76 mm (sec.)	Borite -4.76 mm (sec.)	Silica -600 µm (sec.)	Limestone -600+125 µm (sec.)	Talc/Dolomite -600 µm (sec.)
15 g	45	15	45	20	30
50 g	300	60	300	90	300
100 g	600*	90	600	300	300**

* 96.8% -75 µm
**97.2% -75 µm

With respect to contamination of silica glass sand by extraneous alumina from ceramic grinding surfaces, the results in Fig. 7 show that above 0.9% Al_2O_3 the error between the true and the spurious value becomes negligible. This value, however, is higher than the specification required for silica glass sand of 0.15% Al_2O_3, so that high grade silica sand samples should not be ground in the unit.

CONCLUSIONS

The vibratory ring pulverisor will grind 15 g to 100 g of a variety of non-metallic minerals, representing a range of hardness from 2 to 7, to minus 25 µm.

When used to prepare samples for chemical analysis the unit is not suitable for grinding non-metallic minerals with an alumina content of less than 0.9% Al_2O_3, and in particular high grade silica sand with an alumina content of less than 0.15% Al_2O_3, due to contamination with extraneous alumina obtained from the ceramic surfaces. Above 0.9% Al_2O_3 the error between the true and the spurious alumina analysis becomes negligible.

REFERENCE

1. Anon. "Manufacturers technical information"; T.M. Engineering, Vancouver, B.C.

APPENDIX

DETAILED SIZE ANALYSES OF GROUND PRODUCTS

Table 4 - Cumulative % passing size analyses for 3 different weights of minus 4.76 mm silica ground for varying times

A. Weight of silica: 15 g

Size (μm)	0 sec	15 sec	30 sec	45 sec	60 sec	90 sec	120 sec
-4,760+150	100.0	100.0					
-150+ 75	7.3	93.4	100.0	100.0			
-75+ 44	4.0	57.2	95.8	99.3	100.0	100.0	
-44+ 25	2.7	31.9	80.2	92.3	97.9	99.3	100.0
-25	2.0	29.7	78.2	91.6	97.2	98.6	99.7

B. Weight of silica: 50 g

Size (μm)	60 sec	150 sec	300 sec	450 sec
-4,760+150	100.0			
-150+ 75	89.8	100.0		
-75+ 44	66.0	98.0	100.0	100.0
-44+ 25	50.8	90.3	99.2	99.8
-25	49.8	88.9	98.6	99.6

C. Weight of silica: 100 g

Size (μm)	150 sec	300 sec	450 sec	600 sec
-4,760+150				
-150+ 75	100.0	100.0	100.0	100.0
-75+ 44	56.4	80.1	87.6	96.8
-44+ 25	44.8	65.5	72.1	81.2
-25	32.7	64.5	71.4	80.7

Table 5 - Cumulative % passing size analyses for 3 different weights of -4.76 mm barite ground for varying times

A. Weight of barite: 15 g

Size (μm)	0 sec	15 sec	30 sec	45 sec	90 sec	120 sec
-4,760+150	100.0					
-150+ 75	15.1	100.0				
-75+ 44	10.1	99.9	100.0			
-44+ 25	8.2	95.3	98.2	100.0	100.0	100.0
-25	6.8	78.8	86.9	97.5	99.5	99.5

B. Weight of barite: 50 g

Size (μm)	15 sec	30 sec	45 sec	60 sec	90 sec	120 sec	150 sec	300 sec
-4,760+150	100.0	100.0						
-150+ 75	98.7	99.9	100.0	100.0				
-75+ 44	83.1	95.8	98.7	99.2	100.0	100.0	100.0	100.0
-44+ 25	71.2	87.6	93.6	94.3	99.0	98.1	99.3	98.9
-25	57.1	73.8	82.0	83.2	92.6	90.7	94.7	94.4

C. Weight of barite: 100 g

Size (μm)	30 sec	45 sec	60 sec	90 sec	120 sec	150 sec	300 sec	450 sec
-4,760+150	100.0	100.0						
-150+ 75	97.5	99.9	100.0	100.0	100.0	100.0		
-75+ 44	83.3	95.6	96.2	99.6	99.3	99.9	100.0	100.0
-44+ 25	73.0	85.7	88.0	96.3	92.5	98.6	98.2	98.8
-25	60.1	70.7	76.1	85.4	87.0	91.5	93.8	93.2

Table 6 - Cumulative % passing size analyses for 3 different weights of -600 μm silica ground for varying times

A. Weight of silica: 15 g

Size (μm)	0 sec	15 sec	30 sec	45 sec	60 sec	90 sec
-600+150	100.0	100.0				
-150+ 75	12.9	96.5	100.0	100.0		
-75+ 44	4.1	72.7	95.1	99.3	100.0	100.0
-44+ 25	1.4	53.8	79.0	92.3	97.8	99.3
-25	0.7	52.4	78.3	90.2	97.1	99.1

B. Weight of silica: 50 g

Size (μm)	60 sec	150 sec	300 sec	450 sec	600 sec
-600+150	100.0				
-150+ 75	96.3	100.0			
-75+ 44	75.4	98.0	100.0	100.0	100.0
-44+ 25	56.5	84.8	96.4	99.2	99.4
-25	55.7	83.8	95.8	99.2	99.2

C. Weight of silica: 100 g

Size (μm)	150 sec	300 sec	450 sec	600 sec
-600+150	100.0	100.0		
-150+ 75	83.3	99.6	100.0	100.0
-75+ 44	60.5	81.4	94.9	99.7
-44+ 25	49.0	67.4	78.1	95.1
-25	48.7	67.1	77.7	94.6

Table 7 - Cumulative % passing size analyses for 3 different weights of -600 + 125 µm limestone ground for varying times

A. Weight of limestone: 15 g

Size (µm)	15 sec	20 sec	25 sec	45 sec	60 sec	90 sec
-600+150						
-150+ 75	100.0					
-75+ 44	93.7					
-44+ 25	65.6	100.0	100.0	100.0	100.0	100.0
-25	31.2	88.0	93.3	92.1	96.7	98.0

B. Weight of limestone: 50 g

Size (µm)	15 sec	30 sec	45 sec	60 sec	90 sec	120 sec	300 sec
-600+150							
-150+ 75				100.0	100.0	100.0	
-75+ 44				98.4	99.8	99.8	
-44+ 25	100.0	100.0	100.0	92.0	98.4	99.4	100.0
-25	45.6	61.2	78.0	91.6	98.0	99.2	99.4

C. Weight of limestone: 100 g

Size (µm)	90 sec	150 sec	300 sec	450 sec
-600+150	100.0			
-150+ 75	99.8	100.0	100.0	100.0
-75+ 44	86.6	97.9	99.9	99.8
-44+ 25	75.6	89.3	97.4	99.0
-25	67.7	88.5	96.3	98.5

Table 8 - Cumulative % passing size analyses for 3 different weights of -600 μm talc/dolomite ground for varying times

A. Weight of talc ore: 15 g

Size (μm)	0 sec	15 sec	30 sec	45 sec	60 sec	90 sec	120 sec
-600+150	100.0						
-150+ 75	42.0	100.0					
-75+ 44	26.7	98.0	100.0				
-44+ 25	20.7	88.7	96.0	100.0	100.0	100.0	100.0
-25	14.7	69.4	84.0	88.0	92.0	96.7	98.0

B. Weight of talc ore: 50 g

Size (μm)	15 sec	30 sec	45 sec	60 sec	90 sec	150 sec	300 sec
-600+150	100.0	100.0	100.0	100.0			
-150+ 75	97.4	99.6	99.8	99.8	100.0	100.0	100.0
-75+ 44	76.6	88.2	91.6	96.4	96.3	98.7	99.5
-44+ 25	61.6	72.6	76.8	86.2	83.5	91.7	95.2
-25	45.2	55.4	59.2	67.6	70.4	78.1	84.9

C. Weight of talc ore: 100 g

Size (μm)	30 sec	45 sec	60 sec	90 sec	120 sec	150 sec	300 sec
-600+150	100.0	100.0	100.0	100.0	100.0	100.0	
-150+ 75	91.6	97.4	99.0	99.6	99.7	99.9	100.0
-75+ 44	71.6	80.5	85.7	87.2	92.6	95.3	97.2
-44+ 25	59.8	67.6	72.5	73.6	81.8	86.0	91.8
-25	46.0	52.6	56.8	59.3	64.7	69.4	79.2

Table 9 - Comparison of spurious alumina analyses with true alumina analyses

Analysis with agate mortar (true) % Al_2O_3	Analysis with Vib. Pulver. (spurious) % Al_2O_3	Number of samples tested	% Error
0.06	0.33	13	450
0.08	0.35	2	338
0.09	0.28	2	211
0.10	0.34	2	240
0.11	0.24	1	118
0.12	0.30	1	150
0.14	0.34	1	143
0.16	0.33	1	106
0.18	0.40	2	122
0.23	0.50	1	117
0.26	0.44	2	69
0.30	0.47	2	57
0.32	0.56	1	75
0.33	0.57	1	73
0.35	0.48	1	37
0.37	0.64	1	73
0.39	0.55	1	41
0.40	0.62	1	55
0.42	0.63	1	50
0.56	0.62	1	11
0.66	0.76	1	15
0.92	0.96	1	4
1.50	1.59	1	6
4.00	4.22	1	5